

LIFETIME-LIMITED, HIGH-RESOLUTION X-RAY SPECTRA FROM
LOW-TEMPERATURE, HIGHLY CHARGED IONS

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The Electron Beam Ion Traps (EBIT) at Livermore were designed for studying the x-ray emission of highly charged ions produced and excited by a monoenergetic electron beam. The precision with which the x-ray emission can be analyzed has recently entered a new era when it became possible to decouple the temperature of the ions from the energy of the electron beam by several orders of magnitude. By adjusting the trap parameters, ion temperatures as low as 17 eV for Ti^{20+} and 59 eV for Cs^{47+} were achieved. These temperatures were more than two orders of magnitude lower than the energy of the multi-keV electron beam used for the production and excitation of the ions. Such low ion temperatures not only result in much higher precision but also enable measurements heretofore impossible. For example, the low ion temperature enabled a direct observation of the natural line width of electric dipole allowed x-ray transitions. From the observed natural line width and by making use of the time-energy relations of the Uncertainty Principle we were able to determine radiative transition rates in the femtosecond regime. Other examples of high-resolution measurements enabled by decoupling the electron energy from the ion temperature include measurements of the energy shifts of lines from different isotopes, in particular ^{233}U , ^{235}U , and ^{238}U , that are used to determine the isotopic variation of the nuclear charge radii. Furthermore, the degree of overlap of accidental coincidences of lines from different ions that are of interest to the photopumping of lasers as well as hyperfine effects can be studied with very high precision. A discussion of the techniques used to achieve the decoupling of the ion and electron temperature will be given, and several examples of the high-precision measurements enabled by the reduction in thermal energy of the ions will be presented.

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